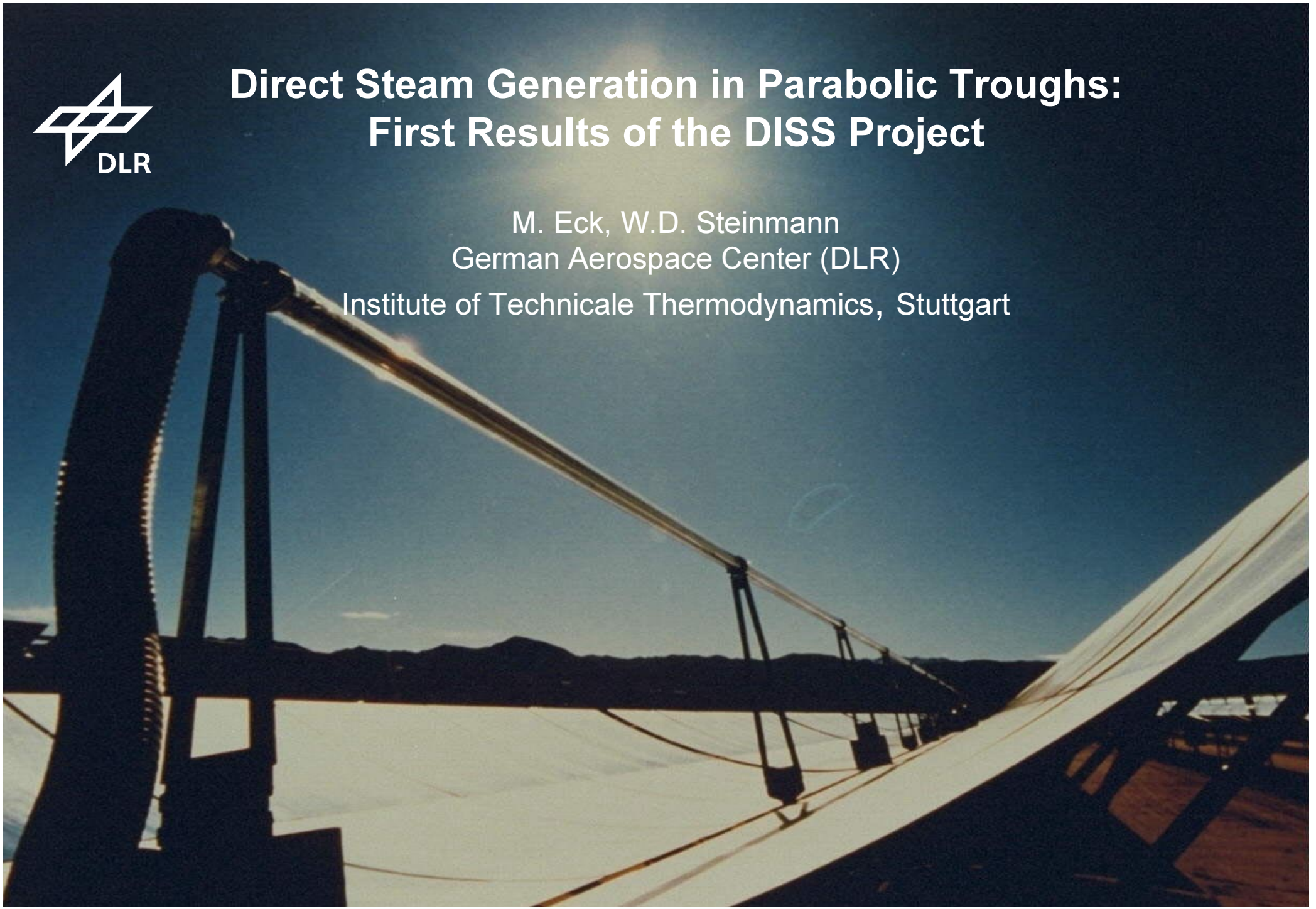

Direct Steam Generation in Parabolic Troughs: First Results of the DISS Project

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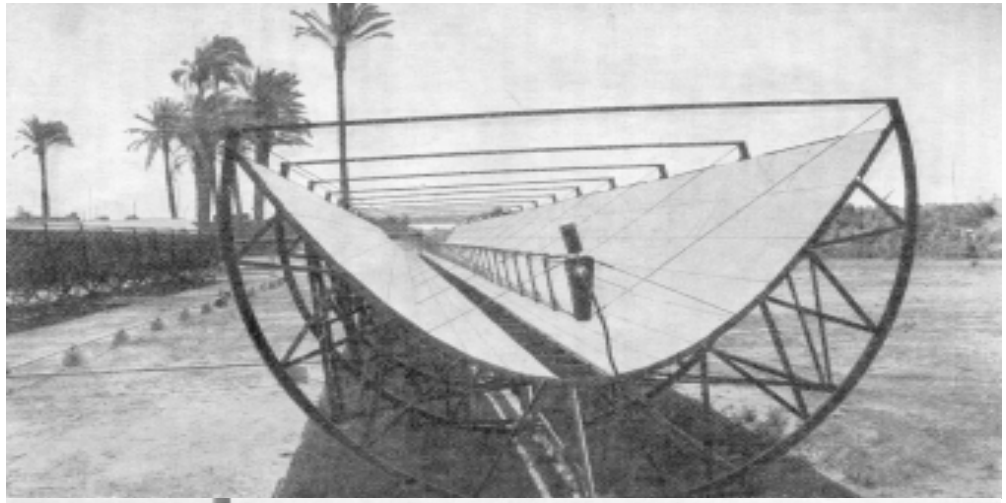
Direct Steam Generation in Parabolic Troughs: First Results of the DISS Project

- Introduction
- Experimental Results
- Conclusions/Outlook

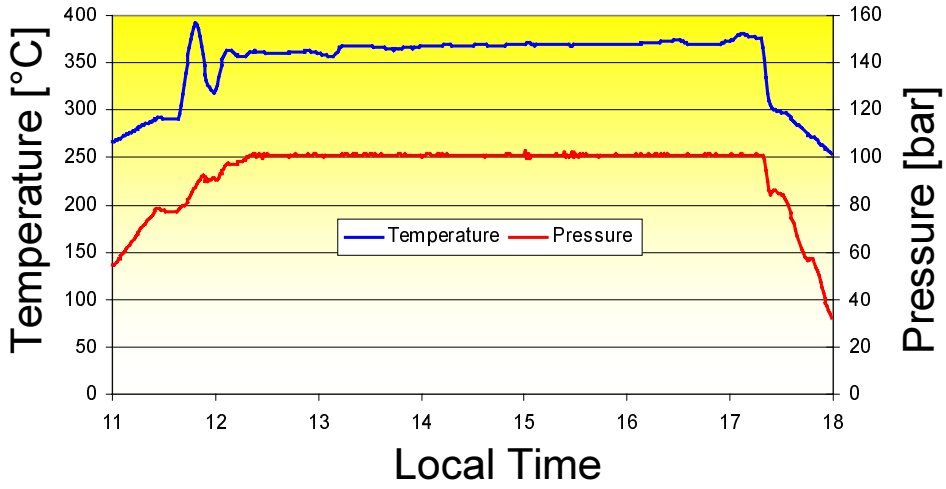
Direct Steam Generation in Parabolic Troughs: First Results of the DISS Project



Structure of the DISS experiments

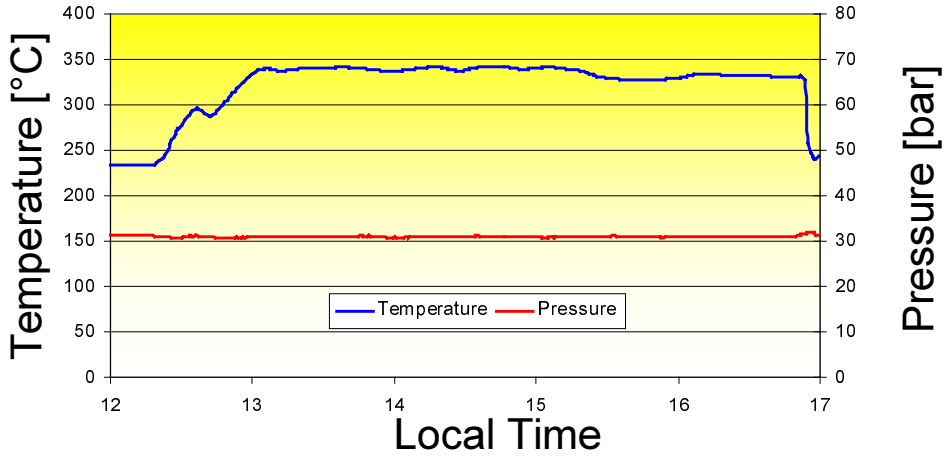
- Start-Up and Shut-Down
- Steady state tests
- Transient tests
- Control tests

Steady-State Tests: Recirculation Concept vs. Once-Through Concept



Recirculation Concept

- Pressure control in automatic mode
- Temperature control in automatic mode for the Once-Through concept
- Demonstration of the feasibility for both concepts



Once-Through Concept

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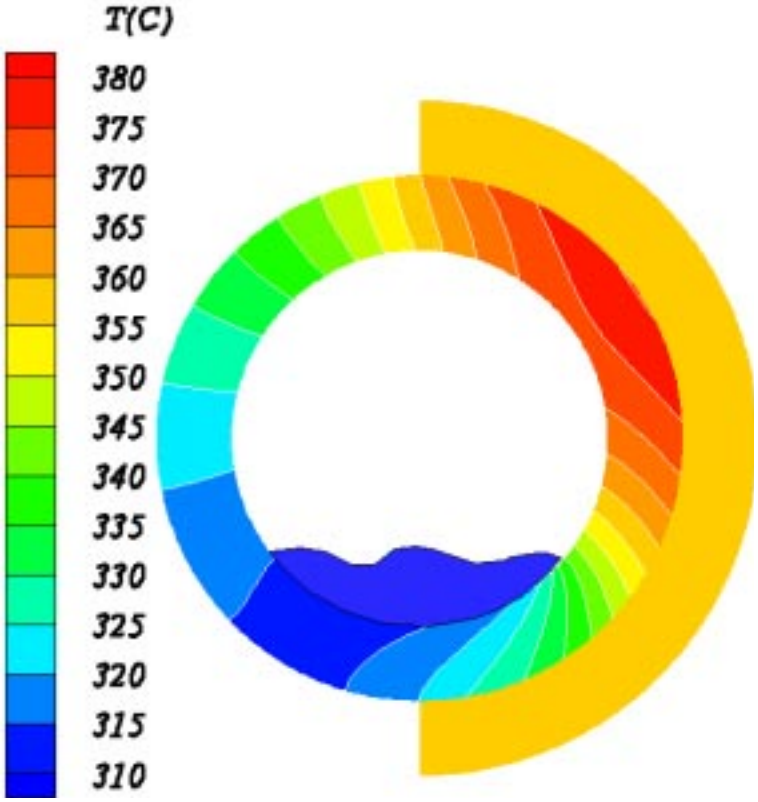
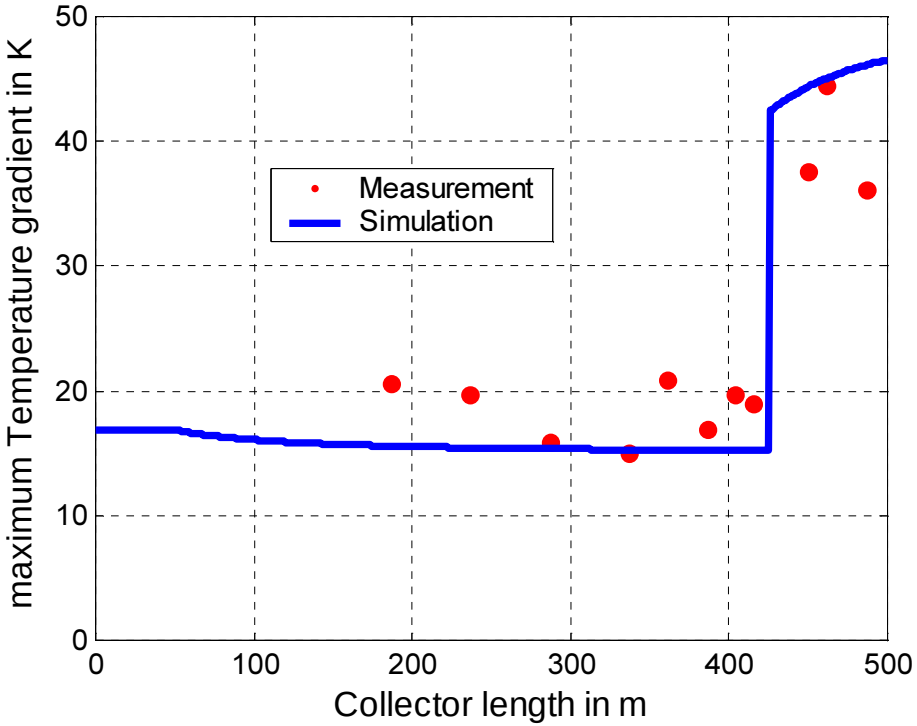
Steady-State Tests: Thermohydraulic of the Direct Solar Steam Generation

Absorber tube

Temperature profile in a cross-section of an absorber tube



Steady-State Tests: Simulation and Measurement of the max. Temperature Gradient in a Cross Section



- Recirculation mode
- p = 30 bar
- Good cooling in the evaporator section (annular flow)
- Simulation model
  - empirical models for the prediction of the flow pattern and heat transfer coefficient
  - FEM calculation of the temperature distribution

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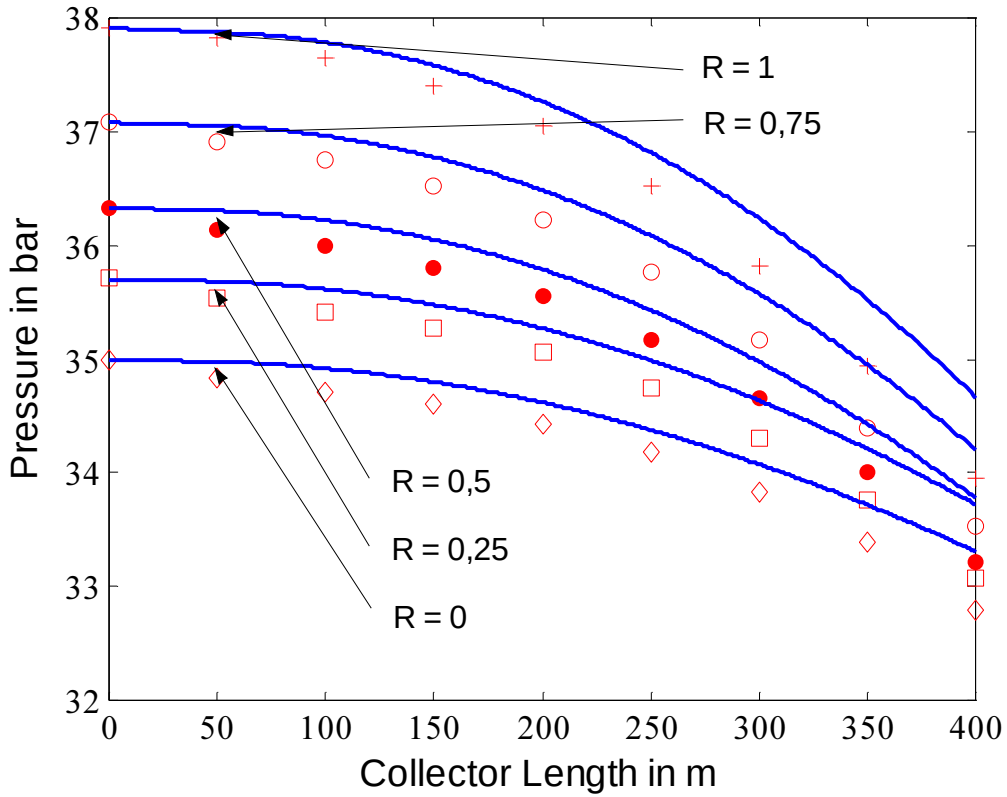
Steady-State Tests: Simulation and Measurement of the Pressure Drop



- Recirculation mode
- p = 30 bar
- $R = \frac{\text{Recirculated Mass Flux}}{\text{Feed Mass Flux}}$
- Higher recirculation rate causes higher pressure drop

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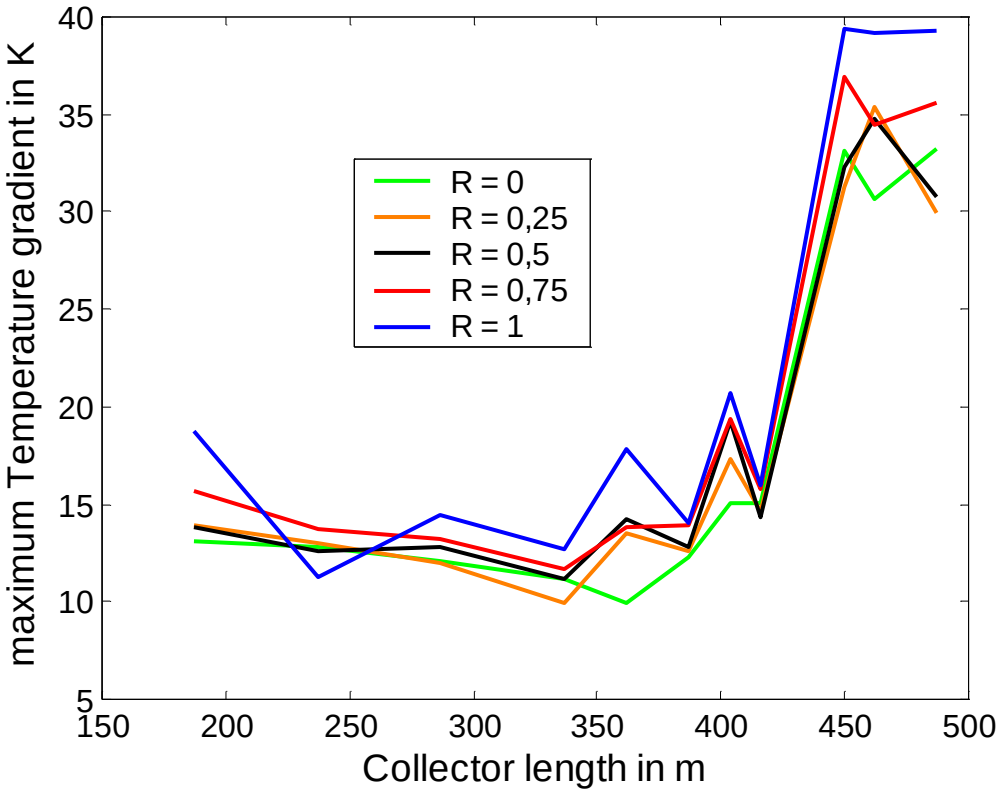
Steady-State Tests: Maximum Temperature Gradient as a Function of *R*



- Recirculation mode
- p = 30 bar
- R = 0 is equivalent to Once-Through-Mode
- No explicit dependency between R and ΔT
- $\Rightarrow$ Sufficient cooling at low recirculation rates

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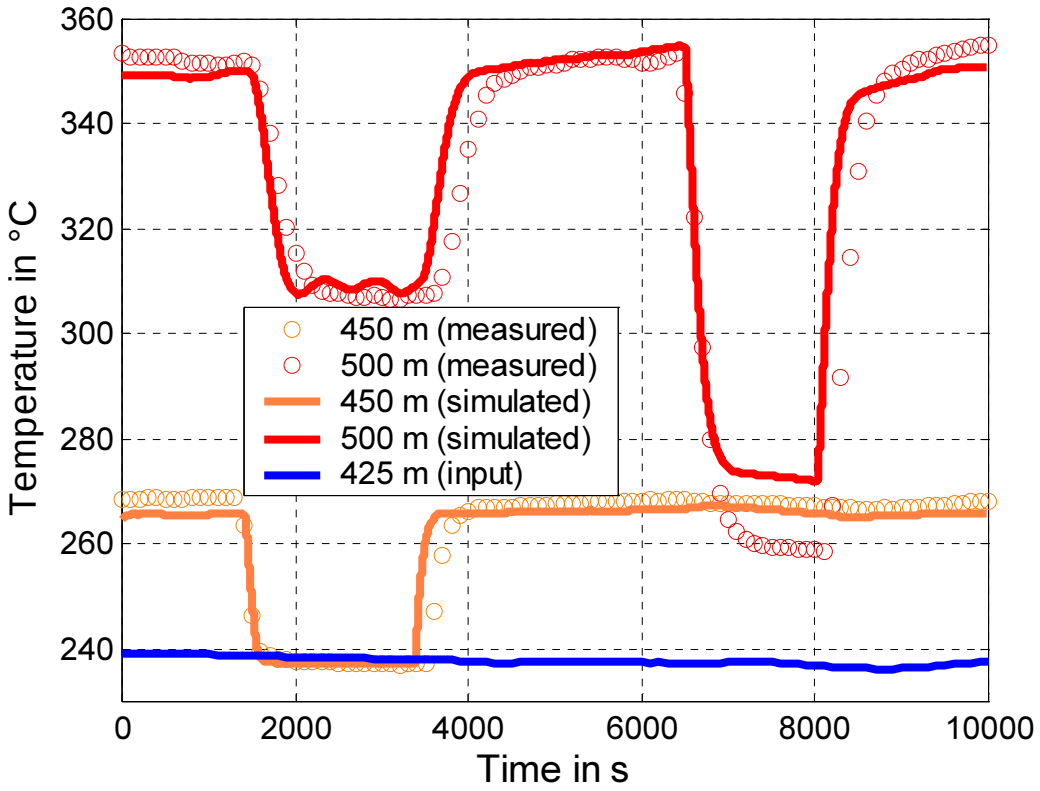
Transient Tests: Simulation and Measurement of the Steam Temperature after the Defocussing of the Superheating Collectors



- Recirculation mode
- p = 30 bar
- Defocussing of the 10th and 11th collector
- Good agreement between simulation and measurement
- Non-problematic dynamic behavior

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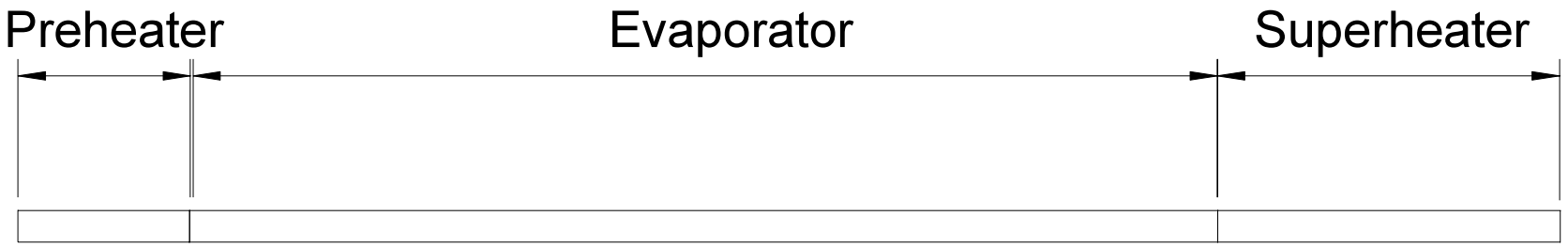
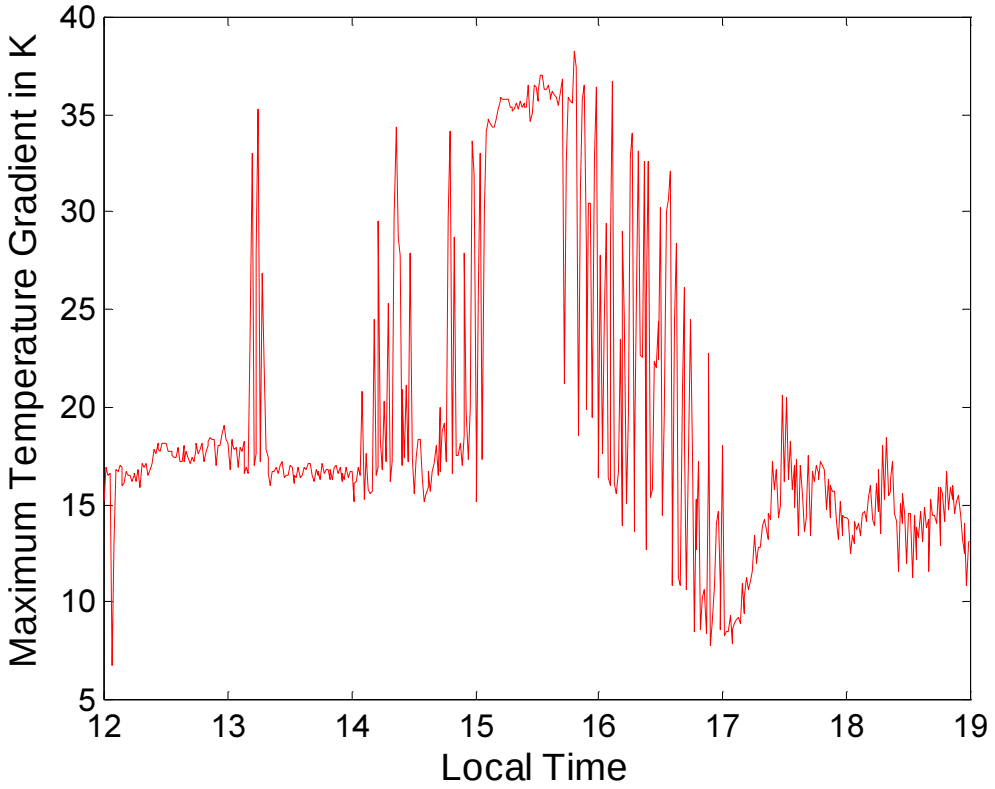
Transient Tests: End of the Evaporation Section



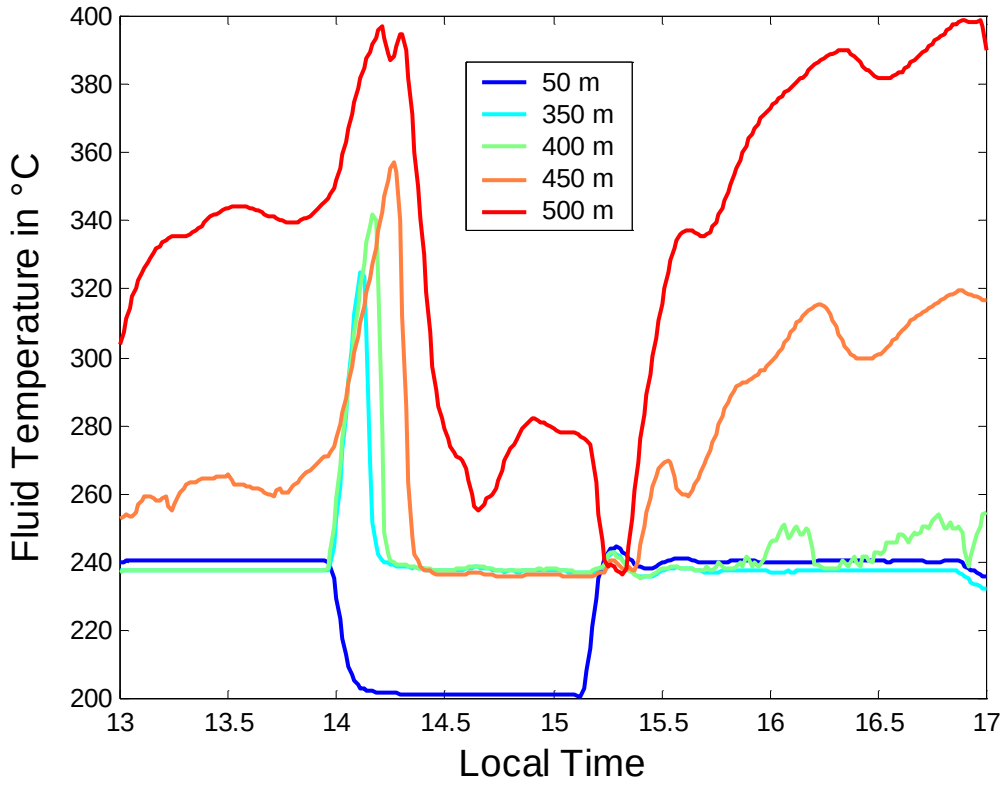
- End of evaporation section is fixed for the recirculation mode (position of the separator)
- Fluctuations of the solar irradiation causes variations of the end of the evaporation section for the Once-Through concept

Steady State Tests: Measurement of the Maximum Temperature Gradient at a Collector Position of 404 m



- Once-Through mode
- p = 30 bar
- Maximum temperature gradient changes between 35 K (superheating section) and 15 K (evaporation section)
- Even under state conditions permanent fluctuations of the end of the evaporation section
- $\Rightarrow$ High thermal stress

Transient Tests:
Measurement of Steam Temperatures at selected collector positions after the Defocussing of the first Collector



- Once-Through mode
- p = 30 bar
- Defocussing of the 1st collector at 14:00
- First increase of the fluid temperatures due to a temporary decreasing of the mass flux
- Afterwards a sudden decrease of the temperature (-120 K in a few seconds)
- $\Rightarrow$ High thermal stress

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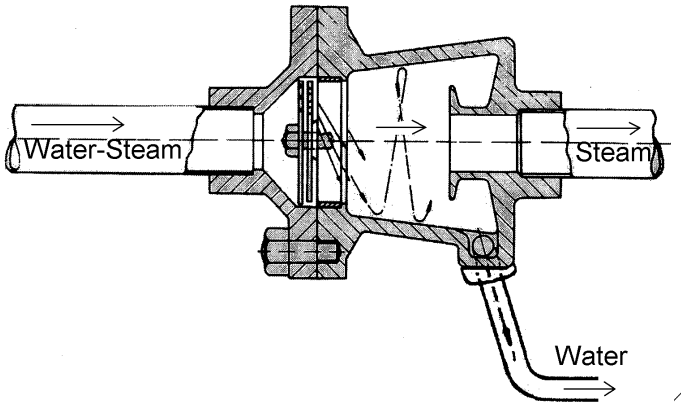
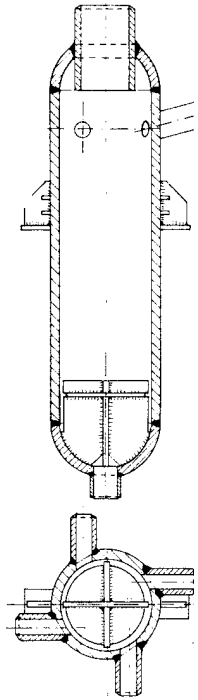
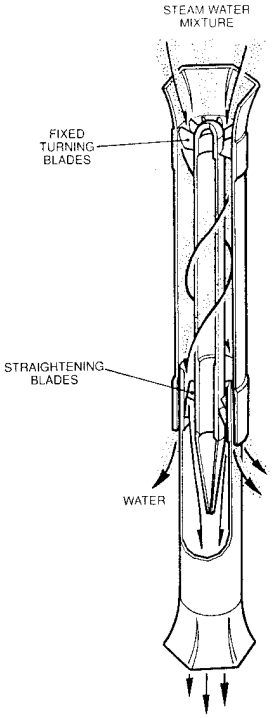
Conclusions:

- The feasibility of the DSG in horizontal collectors has been demonstrated
- A simulation tool for the conceptual design of a DSG collector field was developed
- The recirculation concept has the higher investment
- The recirculation mode is also feasible for low recirculation rates
- The recirculation concept has a fixed end of the evaporation section and therefore guarantees a safe operation of the collector loop
- Compact separators might be an cost effective alternative to separator drums, thus reducing the investment

Conclusions: Alternative Separators

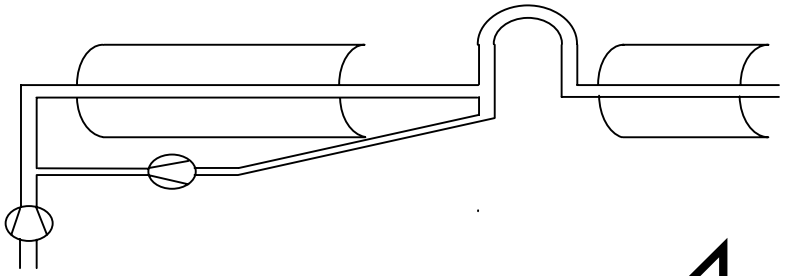






- Cyclone separators
- T-junctions

- Advantages
  - lower price
  - lower thermal inertia



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Outlook:

- Investigation of the Injection mode
- Investigation of compact separator systems
- Investigation of storage systems for DSG
- Investigation of system integration